WehranEnviroTech

Human Health and Environmental Risk Evaluation For Fill Material

Prepared for

TEXTRON LYCOMING
550 Main Street
Stratford, Connecticut

March 3, 1993

Wehran Engineering Corporation
Glastonbury, CT

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1.0 Introduction

1.1 Site Background

The Textron Lycoming facility is located in Stratford, Connecticut. The facility manufactures jet engines for tanks and aircrafts, and employs over 3,000 people.

Textron Lycoming has excavated approximately 10,000 cubic yards of soil from construction sites at Buildings 34 and 65 at this facility. Currently, the soil is stockpiled onsite. Textron Lycoming plans to use this soil to fill depressions in a parking lot on the southern portion of the facility (refer to Figure 1-1), to correct several large saddle depressions. The soil would be compacted and an asphalt topping would be used to serve as a cap for the soil, and provide a finished parking surface level with the surrounding parking area.

A small quantity (approximately 200 cubic yards) of construction debris is currently being accumulated from a construction project for Building 16 at the facility. Textron Lycoming plans to break up the concrete and utilize the debris in conjunction with the soil in correcting the depressions in the parking area.

The parking lot and proposed fill area is located approximately 300 feet from the Housatonic River, which empties into the Long Island Sound. A tidal drainage ditch is located south and east of the parking area. The direction of groundwater flow at the facility is generally southeast toward the river. However, measurement of local groundwater monitoring well elevations indicate that localized groundwater flow direction radiates outward to the east, south, and west (Wehran 1992).

The localized flow of surface water over the area follows a slight topographic gradient which is generally southeasterly toward the tidal drainage ditch. Surface water run-off across the overall facility flows to the east toward the Housatonic River. Run-off from the facility south of Sniffens Lane is either collected in catch basins and discharged to the tidal drainage ditch, or flows to the south toward the tidal drainage ditch and the adjacent marine basin (Wehran 1992).

Groundwater in the area of the facility has been classified by the State of Connecticut as GB/GA, meaning that it is groundwater which may not be suitable for direct human consumption without treatment due to waste discharges, spills or leaks of chemicals or land use impacts. Surface water in the area of the facility has been classified by the State of Connecticut as SC/SB, meaning that it is presently not meeting water quality criteria or one of the more designated uses due to pollution.

1.2 Objective and Scope

Textron Lycoming has requested approval from the Connecticut Department of Environmental Protection (DEP) for onsite reuse of the soil and construction debris as described above. The objective of this risk evaluation is to provide the DEP with documentation of any potential public

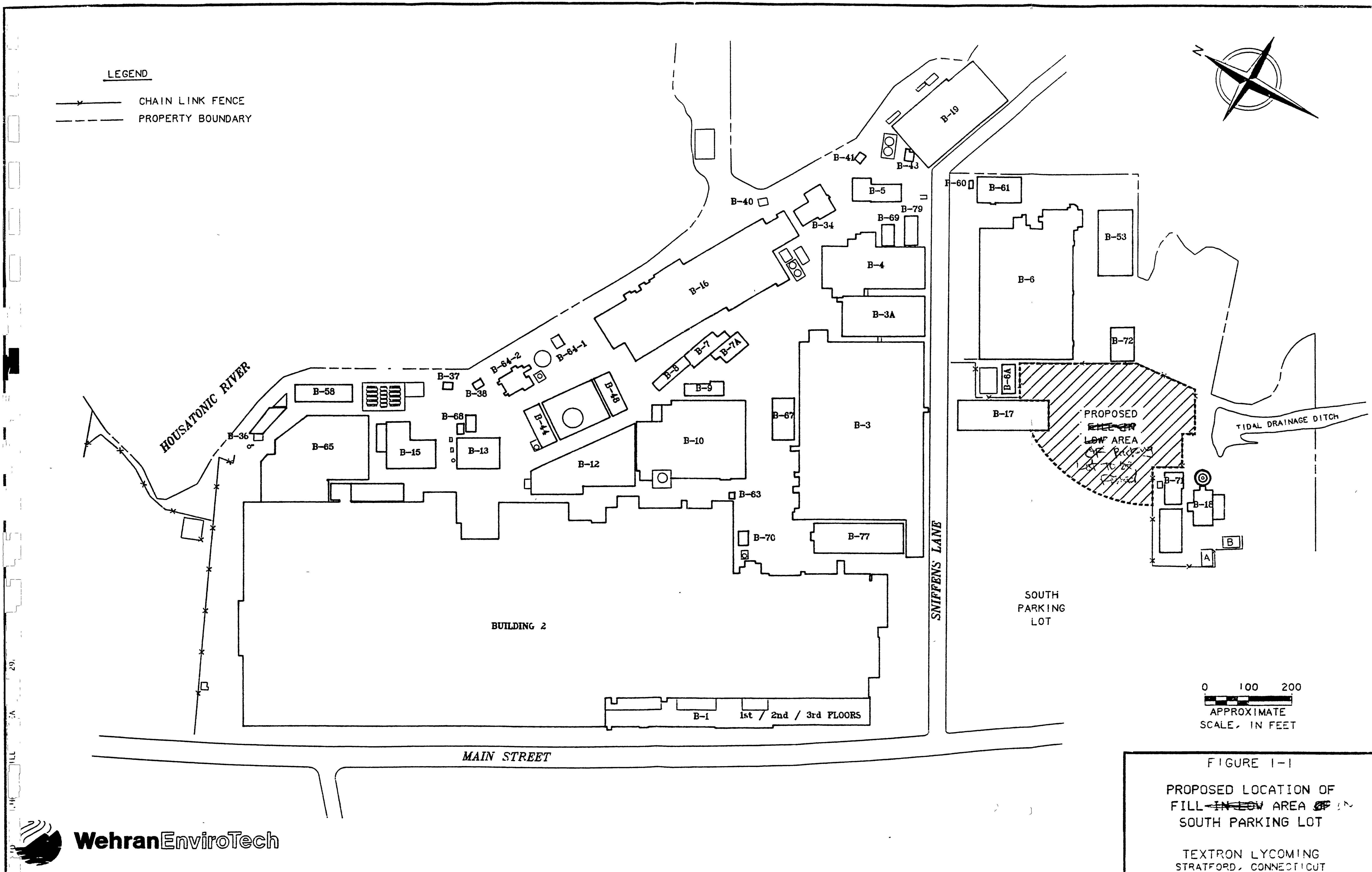

FIGURE 1-1

PROPOSED LOCATION OF
FILL-~~IN LOW~~ AREA ~~OF~~ IN
SOUTH PARKING LOT

TEXTRON LYCOMING
STRATFORD, CONNECTICUT

health or the environmental risks posed by the reuse of the soil and construction debris at the facility. The State of Connecticut, Department of Health Services (DHS) currently recommends utilizing the most recent guidance from the United States Environmental Protection Agency (USEPA) in performing risk assessments for Connecticut sites (DHS 1992).

This evaluation is presented in five sections. Following this introduction, Section 2 identifies the compounds detected in the contaminated soil and construction debris, their associated toxicity, and analyzes the dose response relationships. Section 3 provides information on potential exposure pathways (currently and in the future) for both human and environmental receptor groups which have been identified. Exposure concentrations and assumptions used in developing exposure scenarios are also presented. Section 4 evaluates the potential risk to human health based upon potential cancer and noncancer risks (quantitative) and an evaluation of total petroleum hydrocarbons (qualitative). The potential risks to the environment are also discussed. Uncertainties associated with the risk assessment are also presented. Section 5 presents the summary and conclusions of the risk evaluation.

2.0 Hazard Identification

2.1 Identification of Contaminants

Table 2-1 provides the range of concentrations of the contaminants detected in the stockpiled soils and the Building 16 construction debris. Total petroleum hydrocarbon (TPH) concentrations ranged from 83 ppm to 2,960 ppm in the stockpiled soils, with an average of 464 ppm. The only volatile organic compound (VOC) detected in the stockpiled soil was 1,1-dichloroethylene (1,1-DCE), ranging from less than the detection limit of 2.0 ppb to a maximum concentration of 947 ppb. Analyses of the Building 16 construction debris revealed maximum concentrations of 1,1,1-trichloroethane (1,1,1-TCA) at 3.9 ppb and total mercury (maximum 7.2 ppm). TPH concentrations ranged from 62 ppm to 146 ppm in the Building 16 debris.

While stockpiled soil was analyzed using the Toxicity Characteristic Leaching Procedure (TCLP), this data is not relevant for use in a human health risk evaluation. However, these data are reviewed in the discussion of the potential risk to the environment.

Appendix A contains a brief summary of the toxicological effects of each of the chemicals detected in the soil and construction debris.

2.2 Dose Response Assessment

The dose response assessment is an evaluation of the relationship between the dose of a chemical and the incidence of the adverse effect in the exposed population. Carcinogenic effects are evaluated separately from noncarcinogenic effects. Carcinogenic effects are assumed to have no threshold (i.e. any level of exposure has an associated risk). However, effects other than cancer are assumed to have a threshold (i.e. level below which toxic effects are not anticipated to occur). Measures of toxicological potency to be used in this risk evaluation are potency values (PV) for carcinogens and reference dose values (RfDs) for toxic effects other than cancer, and are provided in Table 2-2.

Noncarcinogenic Effects

The reference dose (RfD) is an estimate of a daily exposure to the human population that is likely to be without appreciable risk of deleterious effects during a lifetime. A subchronic RfD is used to evaluate potential noncarcinogenic effects for exposure periods between two weeks and seven years. The RfD is derived by dividing the no-observed-adverse-effect level (NOAEL) for subchronic or chronic exposure by uncertainty factors. RfDs are route specific (i.e. oral, inhalation) and are expressed in units of mg/kg/day.

Table 2-1
TEXTRON LYCOMING
RANGE OF CONCENTRATIONS DETECTED IN STOCKPILED SOILS AND CONSTRUCTION DEBRIS

Chemical	Stockpiled Soils		Construction Debris	
	Range of Concentration	Mean of Concentration	Range of Concentration	Mean of Concentrat ion
Volatile Organic Compounds (μg/kg) 1,1-Dichloroethylene	<DL (2.0) - 947	106	<DL (2.0)	<DL (2.0)
1,1,1-Trichloroethane	<DL (2.0)	<DL (2.0)	<DL (1.0) - 7.0	1.1
Inorganic Compounds (mg/kg) Mercury	NA	NA	0.06 - 14.5	3.0
Total Petroleum Compounds (mg/kg)	83 - 2,960	464	8.0 - 716	220

Key - <DL = Less than the limit of detection given in parenthesis.
NA = Not Analyzed.

Table 2-2
TEXTRON LYCOMING
TOXICITY VALUES FOR NONCANCER AND CANCER HEALTH EFFECTS

Chemical	Noncancer		Cancer	EPA Weight of Evidence [a]
	Oral Subchronic Value (mg/kg/day)	Oral Chronic Value (mg/kg/day)	Oral Potency Value $(mg/kg/day)^{-1}$	
1,1-Dichloroethylene	9×10^{-3}	9×10^{-3}	6×10^{-1}	C
1,1,1-Trichloroethane	9×10^{-1}	9×10^{-2}	--	D
Mercury	3×10^{-4}	3×10^{-4}	--	D
Total Petroleum Hydrocarbons	--	--	--	--

Source: USEPA Heast, 1992
Key: -- Toxicity Value or EPA Weight of Evidence is not available for this compound.
a = EPA Weight of Evidence
- Group A - Known Human Carcinogen
- Group B - Probable Human Carcinogen
- Group C - Possible Human Carcinogen
- Group D - Not Classified
- Group E - No evidence of Carcinogenicity in Humans

Carcinogenic Effects

Cancer potency values have been developed by the USEPA Carcinogen Assessment Group. Using data from animal studies, the potency value is an estimate of the upper 95% confidence limit of the slope of the dose response curve extrapolated to low doses. Potency values have been derived for both the oral and inhalation routes of exposure, and are expressed in units of $(mg/kg/day)^{-1}$.

The USEPA also assigns a weight of evidence to chemicals, as shown in Table 2-2. This designation represents the degree of confidence that a chemical is a human carcinogen.

3.0 Exposure Assessment

3.1 Potential Human and Environmental Receptors

The current use of the site is industrial, as the Textron Lycoming facility is an active manufacturing operation. Since the stockpiled soil and Building 16 debris will be placed underneath a layer of asphalt in a parking lot, the potential for human contact to occur is currently very minimal. However, if future construction activities were to occur in the parking lot (i.e. the parking lot was expanded), future contact with the soil by construction workers could occur.

While future use of the site is likely to remain industrial, this evaluation also considers the potential for the area to become residential, with the soil and construction debris exposed at the surface. This is necessary in order to determine if long-term site controls are necessary to prevent the parking lot area from becoming rezoned residential in the future. Table 3-1 presents a summary of the exposure profiles for human receptor groups being evaluated.

According to the Stratford Health Department, no private drinking water wells are known to exist within one mile of the facility (Stratford Health Department 1992). The area is served by a municipal water supply operated by Bridgewater Hydraulic.

Environmental receptors to be evaluated include the nearby tidal drainage ditch and the Housatonic River, which eventually flows into the Long Island Sound just southeast of the site.

3.2 Pathways of Exposure

As previously discussed, the potential for human exposure to the fill under the pavement through current site conditions is very small. However, if the asphalt layer were to be disrupted in the future (by construction activities) or if the site were to be rezoned residential, exposure to the soil and debris could occur by dermal (skin) contact or incidental ingestion. Therefore, human health risks associated with these pathways will be evaluated. Human health risks will not be evaluated for consumption of groundwater, as groundwater in the area is not currently used for drinking water, nor is it expected to be in the future.

The parking lot area proposed to contain the fill is located in a flood plain, and in close proximity to the tidal drainage ditch and the Housatonic River (i.e. environmental receptors). The potential for the identified contaminants to migrate and impact these water bodies is a function of the concentrations detected at the site, the distance of these surface water bodies from the site, the expected rate of migration of these contaminants from soil to groundwater, combined with the rate of flow of site groundwater to the surface water.

Table 3-1

TEXTRON LYCOMING

EXPOSURE PROFILES FOR HUMAN RECEPTOR GROUPS

Receptor	Exposure Point	Activity	Medium	Exposure Route	Frequency & Duration of Contact
Future Construction Workers	Soil and debris under pavement	Construction	Soil Soil	Dermal Contact Ingestion	5 days per week for 3 months
Future Site Residents	Exposed soil and debris	Playing/yard activities	Soil Soil	Dermal Contact Ingestion	7 days per week for 9 months/yr

3.3 Exposure Methods and Assumptions

Tables 3-2 and 3-3 provide the exposure methods and assumptions for ingestion of and dermal contact with soil to onsite construction workers as well as the potential future residential receptors. The soil concentrations used to estimate exposure are the maximum concentrations detected, as requested by the DEP. While many of the standard EPA default exposure assumptions were used, Wehran estimated for the construction workers' exposure scenario that the exposure duration was approximately 5 days per week, for approximately a 3 month duration (i.e duration of any future construction activities in the parking lot). The USEPA currently considers that the typical resident will reside at one location for an average of 30 years. Residents were assumed to have contact with the soil and construction debris for 7 days per week, nine months of the year.

Table 3-2

Exposure Estimation Method and Assumptions for Ingestion of Soil

$$\textit{Exposure Dose (mg/kg/day)} = \frac{C \times IR \times EF \times ED \times RAF}{BW \times AVG \times 365 \textit{ days/year} \times 10^6 \textit{ mg/kg}}$$

Where:

C = Contaminant Concentration in Soil (mg/kg)

IR = Ingestion Rate (mg soil/day)
- Occupational Worker — 50mg/day
- Child (age 1-6) — 200 mg/day
- Adult — 100 mg/day

EF = Exposure Frequency (days/year)
- Occupational Worker — 65 days/year (5 days/week for a 3 month period)
- Child (age 1-6) — 273 days/year (7 days/week for 9 months of the year)
- Adult — 273 days per year

ED = Exposure Duration (years)
- Occupational Worker — 0.25 year
- Child (age 1-6) — 6 years
- Adult — 24 years

RAF = Relative Absorption Factor (per Region I guidance; EPA, 1989b)
- VOCs, 100%
- Inorganics, 100%

BW = Body Weight (kg)
- Adult — 70 kg
- Child — 15 kg

AVG = Number of years over which the exposure is averaged
- 70 years for carcinogenic effects
- ED years for noncarcinogenic effects

TABLE 3-3

Exposure Estimation Method and Assumptions for Dermal Contact with Soil

$$Exposure\ Dose\ (mg/kg/day) = \frac{C \times SCR \times EF \times ED \times RAF}{BW \times AVG \times 365\ days/year \times 10^6\ mg/kg}$$

Where:

C = Contaminant Concentration in Soil (mg/kg)

SCR = Soil Contact Rate (mg/day)
- Occupational — 500 mg/day
- Nonoccupational — 1000 mg/day

EF = Exposure Frequency (days/year)
- Occupational Worker — 65 days/year (5 days/week for a 3 month period)
- Child (age 1-6) — 273 days/year (7 days/week for 9 months of the year)
- Adult — 273 days per year

ED = Exposure Duration (years)
- Occupational Worker — 0.25 year
- Child (age 1-6) — 6 years
- Adult — 24 years

RAF = Relative Absorption Factor (per Region I guidance; EPA, 1989b)
- VOCs, 50%
- Inorganics, 1% (negligible)

BW = Body Weight (kg)
- Adult — 70 kg
- Child — 16 kg

AVG = Number of years over which the exposure is averaged
- 70 years for carcinogenic effects
- ED years for noncarcinogenic effects

4.0 Risk Characterization

4.1 Potential Impacts to Human Health

Noncarcinogenic Effects

In order to assess the potential adverse effects associated with subchronic (worker) and chronic (residential) exposure, the estimated subchronic and chronic exposures (calculated from Tables 3-2 and 3-3) were compared to their acceptable daily dose (AD), which is the reference dose (RfD) as shown in Table 2-2. This comparison is shown in Table 4-1 entitled Hazard Index. Complete supporting calculations are provided in Appendix B.

A noncarcinogenic Hazard Index for a particular exposure point is defined as the sum of the ratios of the estimated daily intake of a chemical to the relevant acceptable daily dose for all chemicals evaluated at the exposure point. Summing of the ratios assumes that their toxicological effects are additive and that the compounds affect the same toxicological endpoints. The ratio from all the exposure pathways and routes applicable to a given receptor should be summed.

According to USEPA guidance, a Hazard Index of less than 1.0 is not expected to result in any adverse toxic effects. The Hazard Indices calculated for both future construction workers and residents of the parking lot area were both less than 1.0 (0.007 and 0.5, respectively). The Hazard Indices for the purposes of screening assume no difference in mechanism of action between the chemicals being quantitatively evaluated (1,1-dichloroethylene, 1,1,1-trichloroethane and mercury). While this is not the case, it was assumed as a simplifying assumption in order to see if additional refinement of the Hazard Index was necessary.

Carcinogenic Effects

The only chemical quantitatively evaluated in the human health risk evaluation that is considered to be potentially carcinogenic is 1,1-dichloroethylene (1,1-DCE). The carcinogenic risk posed by this compound was calculated by multiplying the estimated daily intake for each route of exposure by the potency value for 1,1-DCE. The risks for the relevant receptor groups are then summed to evaluate a total risk for that population, as shown in Table 4-1.

The USEPA normally considers potential risks that fall within the range of one in ten thousand (1E-04) to one in one million (1E-06) or greater to be an acceptable range of risk. The estimated cancer risks for the future construction workers and residents of the parking lot area were both within the range of acceptable risk (2.9E-09 and 1.8E-06, respectively). This risk however, does not consider exposure to the total petroleum hydrocarbons detected at the site.

Table 4-1
TEXTRON LYCOMING
SUMMARY OF POTENTIAL RISK TO HUMAN HEALTH

Receptor Group	Exposure Pathway	Estimated Hazard Index	Estimated Excess Risk of Cancer
Future Construction Workers	Ingestion of Soil	0.006	2.6×10^{-10}
	Dermal Contact with Soil	0.001	2.6×10^{-9}
	Total	0.007	2.9×10^{-9}
Future Site Residents[1]	Ingestion of Soil	0.5	6.7×10^{-7}
	Dermal Contact with Soil	0.01	1.1×10^{-6}
	Total	0.5	1.8×10^{-6}

[1] Estimated hazard index and excess risk of cancer for future site residents are based on the summation of risk to both age groups (1-6 yrs and 6-30 yrs).

Qualitative Risks

Currently, soil clean-up levels for total petroleum hydrocarbons (TPH) are not available. While concentrations ranged from 83 to 2,960 ppm, the average concentration detected was 464 ppm. The source or composition of the TPH is essentially unknown, and the result of low level petroleum contamination of Building 65 area prior to construction. Textron Lycoming believes it is most likely that the TPH was associated with jet fuel, lubricating oil, and/or fuel oils historically used as the facility.

An approach was reviewed which evaluated human cancer risks from ingestion and inhalation of TPH contaminated soil (Stokman and Dime 1986). This approach did not address migration to groundwater. Utilizing benzo(a)pyrene, (a carcinogenic polyaromatic hydrocarbon, CaPAH) and benzene as constituents of concern, a lifetime soil exposure model was used to estimate acceptable soil concentrations of these constituents that would result in a one in one million (1E-06) cancer risk, if exposure were to occur. Acceptable soil concentrations for CaPAHs and benzene were calculated by the authors to be 30 ppb for CaPAHs and 6,900 ppb for benzene. As a conservative assumption, all CaPAHs were assumed to have risks equivalent to that of benzo(a)pyrene (a class A carcinogen). Benzene was not detected in the Textron soil material, and therefore was not a part of the qualitative evaluation.

Stokman and Dime (1986) also measured the residual soil concentrations for CaPAHs of samples containing 100 ppm of various petroleum products. The resulting CaPAH concentrations were as follows: fuel oil (jet fuel) 0.002 ppb; No. 2 fuel oil (diesel oil) 4 ppb; and lubricating oil 0.03 ppb. These data were used to develop an acceptable TPH concentration in soil (guideline value), by adjusting the residual levels of CaPAHs calculated to exist at 100 ppm of TPH to their corresponding 10^{-6} cancer risk concentration. No. 2 fuel oil had the highest residual levels at the 100 ppm TPH level of any petroleum product qualitatively identified. Therefore as a conservative assumption, No. 2 fuel oil was selected as the "worst case" source of TPH. By adjusting the residual level of 4 ppb CaPAH in No. 2 fuel oil at 100 ppm to its associated 1×10^{-6} cancer risk at 30 ppb, a factor of 7.5 is introduced. Therefore, the level of TPH in soil of 100 ppm is increased by a factor of 7.5 (30/4) to 750 ppm. This level of 750 ppm total petroleum hydrocarbons may be used at the site as a guideline value. Soil concentrations greater than this level are considered to constitute a potential risk to human health based on the assumptions and analysis presented above.

4.2 Potential Impacts to the Environment

The primary pathway of environmental concern for contaminant transport is migration down-gradient with bulk groundwater flow. While localized groundwater direction may vary, the overall direction is southeasterly, towards the Housatonic River, which empties into the Long Island Sound. A secondary concern is the potential for flooding of the tidal drainage ditch into the parking lot area.

Extensive TCLP testing of the soils revealed two low detections of volatile organic compounds: chloroform (0.44 ug/l) and 1,1-dichloroethylene (4.7 ug/l), both of which were orders of magnitude below their respective TCLP hazardous limits. TCLP metals were also generally non-detectable, or in orders of magnitude below their respective TCLP hazardous limits. The TCLP results suggest that there is a low potential for leaching from soil to the groundwater, even considering the potential for flooding.

While the Building 16 debris revealed low levels of contamination, the compounds are bound in concrete, which greatly reduces the ability of the compounds to migrate. Mercury was detected at a maximum concentration of 14.5 ppm in the Building 16 construction debris. Mercury tends to bind with the soil and would not be expected to migrate readily in the groundwater. Total Petroleum Hydrocarbons (TPHs) also expected to bind to the soil and not readily leach into the groundwater.

Given that the parking lot will be paved, infiltration will be limited, reducing the potential leachability of the contaminants placed under the pavement. In addition, the pavement itself will reduce potential migration through surface run-off. Therefore, Wehran believes that the environmental receptors identified would not be adversely impacted from the placement of the contaminated soil and debris under the parking lot at the facility.

4.3 Uncertainties Associated with Risk Evaluation

This risk assessment, like all risk assessments, is limited by the data available for the site. The most significant limitation for this evaluation is information regarding the total petroleum hydrocarbon (TPH) composition. The exclusion of the TPHs from the quantitative risk assessment limits the validity of the quantitative conclusions that have been developed.

Table 3-2 and 3-3 provide the assumptions used in the exposure assessment. In some cases these values have a high degree of uncertainty. While the assumptions regarding the frequency and duration of exposure are reasonable assumptions about how the receptors might use the area in question in the future, certainly a range of uses can be expected to occur.

Most of the uncertainties related to risk characterization are common to all risk assessments. These uncertainties relate to the methods available for evaluating the potential for adverse effects based on dose response data from laboratory animals exposed at relatively high concentrations.

The qualitative assessment to public health identified contaminants that could not be assessed quantitatively (total petroleum hydrocarbons), due to the lack of dose response data and composition of the compounds. Quantification of the TPH exposure in the risk assessment could potentially increase the hazard index and estimated cancer risks presented in Section 4.1.

5.0 Summary and Conclusions

A human health and environmental risk evaluation was conducted to evaluate the potential risk of using approximately 10,000 cubic yards of stockpiled soil and approximately 200 cubic yards of construction debris as on-site fill. The soil and debris would be used to fill in depressions in a parking lot at the Textron Lycoming facility in Stratford, Connecticut.

The human health evaluation considered two receptor groups, future construction workers who may come into contact with the soil and debris if construction were to occur in the parking lot, as well as future residents who may reside in the area, if it were to be rezoned residential. The evaluation considered exposure by incidental ingestion and dermal contact with the soil. Ingestion of groundwater was not considered because it was assumed that there was no foreseeable use of groundwater in the area as a drinking water source.

The hazard index was used to quantify the noncancer health risk associated with exposure to the soil and debris. The hazard index for future construction workers was 0.007 and for future site residents, 0.5, well below the USEPA recommended limit of 1.0.

The estimated excess cancer risks for construction workers and future site residents were estimated to be 2.9E-09 and 1.8E-06, respectively. While the estimated excess cancer risk for future site residents falls within the USEPA regulatory guidelines of 10^{-04} to 10^{-06} for remediation, this is not considered to be a significant risk to public health, given the conservative assumptions utilized. 1,1-Dichloroethylene was the only compound evaluated quantitatively for carcinogenicity.

The potential risk to total petroleum hydrocarbons were evaluated qualitatively, and would contribute to the overall risk if they could have been evaluated in the quantitative assessment. A guideline of 750 ppm TPH in soil was developed based on a number of conservative assumptions. The arithmatic mean concentration of TPH in soils was 464 ppm. EPA risk assessment guidance specifies that exposure point concentrations be evaluated by comparing the arithmatic mean values of any contaminants present to available standards of guidelines. Given that the mean concentration of TPH is significantly below the conservative guideline value of 750 ppm, there should be no significant health risks for workers in contact with any TPH contaminated soil material.

The potential risks posed to the environment were also reviewed, and it was concluded that due to the low leachability of the compounds detected along with the lack of mobility in groundwater, the risk to the environment was not considered to be significant.

The State's goal for groundwater and surface water is to prevent further degradation by preventing any additional discharges which would cause irreversible contamination. In summary, Textron Lycoming's reuse of soil and construction debris at the site will not negatively impact the State of Connecticut groundwater (GB/GA) and surface water (SC/SB) quality classifications and goals for the site.

6.0 References

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APPENDIX A

TOXICITY PROFILES

Toxicity profiles have been developed for the compounds detected in the stockpiled soils and construction debris at the Textron Lycoming Facility. Factors that were considered in this toxicological evaluation included pharmacokinetics (i.e., how a chemical is absorbed, distributed, metabolized and eliminated from the body), acute (short-term) and chronic (long-term) toxicity including carcinogenicity, mutagenicity, teratogenicity and reproductive effects. Toxicity profiles are included for the following compounds.

Volatile Organic Compounds

1,1-Dichloroethylene
1,1,1-Trichloroethane

Inorganic Compounds

Mercury

Total Petroleum Compounds

1,1-Dichloroethylene CASRN 75-34-4

1,1-Dichloroethylene (1,1-DCE) is a clear colorless liquid used as a chemical intermediate in the production of methylchloroform and polyvinylidene products. 1,1-DCE is not highly toxic. Its general anesthetic properties have been observed in humans at acute levels of 16,000 mg/m^3. Rats exposed to 189 mg/m^3 chronically developed kidney and liver damage. An epidemiologic study of workers exposed to 9 to 280 mg/m^3 1,1-DCE in the workplace showed no adverse affects (USEPA 1980) and there is limited evidence that it may be teratogenic (USEPA 1980).

1,1-DCE has an oral reference dose (RfD) of 9E-3 mg/kg/day. The principal and supporting studies reported the critical effect of hepatic lesions. The study was a chronic oral bioassay conducted on rats, administered in drinking water. The study was conducted using the appropriate number of animals of two species, measured several endpoints, and was of chronic duration. Since there are corroborating chronic and subchronic oral bioassays, confidence in the study, data base and the RfD are considered medium.

1,1-DCE has a classification of C; possible human carcinogen. This classification is based on studies in which tumors were observed in one mouse strain after inhalation exposure. 1,1-DCE has also been shown to be mutagenic. It is structurally related to the known human carcinogen, vinyl chloride.

1,1,1-Trichloroethane CASRN 71-55-6

1,1,1-Trichloroethane (1,1,1-TCA) is a synthetic, colorless, nonflammable liquid used primarily in the cleaning and vapor degreasing of fabricated metal parts. It is also used in the synthesis of other organic chemicals, and as an additive in metal cutting oils.

1,1,1-TCA is rapidly and completely absorbed through both the lungs and gastrointestinal tract and is preferentially distributed to the central nervous system (USEPA 1984). 1,1,1-TCA is metabolized only to a limited extent by animals and humans.

The primary toxic effects observed in humans after high levels inhalation exposure to 1,1,1-TCA are dizziness, lightheadedness, and loss of coordination and balance. A chronic oral exposure study to 1,1,1-TCA was conducted by NCI (1977) in rats and mice. Maximum dosages received were 1,500 mg/kg bw and 5,600 mg/kg bw for rats and mice, respectively. Diminished body weight gain and decreased survival were observed.

1,1,1-TCA has an oral reference dose (RfD) of 9E-2 mg/kg/day. The principal study reported a NOAEL of 90 mg/kg/day, from a six month guinea pig inhalation study. Confidence in the database was rated medium, and confidence in the RfD was rated medium to low. This is because the number of animals at each dose level was limited and few toxic endpoints were examined.

There are no reported human data regarding carcinogenicity and animal studies have not demonstrated carcinogenicity. Technical grade 1,1,1-TCA has been shown to be weakly mutagenic, although 1,4-dioxane, a known animal carcinogen, may be responsible for this response (USEPA 1991).

Mercury CASRN 7439-97-6

Mercury is a silvery liquid metal used in the manufacture of electrical and chloralkali products, batteries, thermometers and paints. Mercury forms a number of organic compounds such a s methylmercury and ethylmercury. Mercury compounds bind strongly to organic matter and are highly immobile (USEPA 1984).

Mercury is highly toxic once it is absorbed by the body, affecting the central nervous system and kidneys. Symptoms include ataxia, tremors, numbness of the extremities, impaired peripheral vision and slurred speech. Inorganic mercury is poorly absorbed from the gastrointestinal tract with a lethal dose for adults estimated to be 1 to 4 grams (USEPA 1984). Symptoms of methylmercury toxicity have been observed at intake levels in the range 3 to 7 ug/kg/day (USEPA 1984). Inhalation of mercury vapor at concentrations greater than 0.1 mg/m^3 results in damage to the respiratory tract and inflammation of the lungs.

The carcinogenicity assessment for mercury classifies mercury as group D; not classified (USEPA 1991). There is no human data available and animal and supporting studies are inadequate.

Total Petroleum Hydrocarbons

The health effects of refined petroleum products are due to four major groups of hydrocarbon components; alkanes, alkenes, alicyclic and aromatic hydrocarbons. The alkane (paraffin) compounds of the refined petroleum products are primarily aliphatic hydrocarbons from C3 to C8 (NEREPHC 1989). Alkanes have potent narcotic action when inhaled at high doses. Straight chain alkanes are, in general, more toxic than branched chain isomers. Polyneuropathy has developed in animals and humans following chronic intoxication by alkanes (NEREPHC 1989).

Alicyclic hydrocarbons, which include saturated and unsaturated napthenes or cycloparrafins, have toxic effects similar to aliphatic hydrocarbons. Alicyclic compounds and alkene (olefin, unsaturate aliphatics) constituents from petroleum products have limited acute toxicity, are anesthetic, and are central nervous system depressants.

Benzo(a)pyrene, (BAP), a polynuclear aromatic hydrocarbon (PAH), is often used as an indictor compound in assessing petroleum hydrocarbon toxicity. BAP is carcinogenic in animals and experimentally teratogenic and mutagenic (ICF 1987). Exposure to a mixture of compounds (PAHs) that contain BAP as a constituent (as in refined petroleum products), has been associated with human cancer (NEREPHC 1989).

The environmental fate of petroleum hydrocarbons in soil is affected primarily by their distribution, volatilization and leaching potential. Lower molecular weight aromatic hydrocarbons such as benzene, toluene and xylene have a high Henry's Law constant, and tend to partly evaporate. The remainder will migrate to different depths of the soil column where little or no volatilization to the atmosphere occurs (Stokman and Dime 1986).

References

1,1-Dichloroethylene

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1,1,1-Trichloroethane

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3. USEPA Health Effects Assessment Summary Tables (HEAST),1992. OSWER and ORD.

4. Agency for Toxic Substances and Disease Registry (ATSDR), 1989. Toxicological Profile for 1,1,1-Trichloroethane.

Mercury

1. USEPA, 1984. Health Effects Assessment Document for Mercury. Office of Research and Development, Cincinnati, Ohio.

2. USEPA Health Effects Assessment Summary Tables (HEAST),1992. OSWER and ORD.

Total Petroleum Hydrocarbons

1. Northeast Regional Environmental Public Health Center (NEREPHC), 1989. A Critical Evaluation of Indicator Compound Methodologies for No. 2 Fuel Oil. University of Massachusetts, Amherst, MA.

Hazard Index

Future Construction Workers, Subchronic
Ingestion of Soil

$$\textit{Exposure Dose (mg/kg/day)} = \frac{C \times IR \times EF \times ED \times RAF}{BW \times AVG \times 365 \ days/year \times 10^6 \ mg/kg}$$

$$\text{1,1-DCE} = \frac{0.947 \ mg/kg \times 50 \ mg/day \times 65 \ days/yr \times 0.25 \ yr \times 100\%}{70 \ kg \times 0.25 \ yr \times 365 \ day/yr \times 10^6 \ mg/kg}$$

$$= 1.2 \times 10^{-7} \ mg/kg/day$$

$$\text{1,1,1-TCA} = \frac{0.007 \ mg/kg \times 50 \ mg/day \times 65 \ days/yr \times 0.25 \ yr \times 100\%}{70 \ kg \times 0.25 \ yr \times 365 \ day/yr \times 10^6 \ mg/kg}$$

$$= 9.0 \times 10^{-10} \ mg/kg/day$$

$$\text{Mercury} = \frac{14.5 \ mg/kg \times 50 \ mg/day \times 65 \ days/yr \times 0.25 \ yr \times 100\%}{70 \ kg \times 0.25 \ yr \times 365 \ day/yr \times 10^6 \ mg/kg}$$

$$= 1.8 \times 10^{-6} \ mg/kg/day$$

$$\text{Hazard Index} = \text{1,1-DCE: } \frac{1.2 \times 10^{-7}}{9.0 \times 10^{-3}} = 1.3 \times 10^{-5}$$

$$\text{1,1,1-TCA: } \frac{9.0 \times 10^{-10}}{9.0 \times 10^{-1}} = 1.0 \times 10^{-9}$$

$$\text{Mercury: } \frac{1.8 \times 10^{-6}}{3.0 \times 10^{-4}} = 6.0 \times 10^{-3}$$

$$\textit{TOTAL} = 6.0 \times 10^{-3}$$

Future Construction Workers, Subchronic Dermal Contact with Soil

$$\text{Exposure Dose (mg/kg/day)} = \frac{C \times SCR \times EF \times ED \times RAF}{BW \times AVG \times 365 \text{ days/year} \times 10^6 \text{ mg/kg}}$$

$$\text{1,1-DCE} = \frac{0.947 \text{ mg/kg} \times 1000 \text{ mg/day} \times 65 \text{ days/yr} \times 0.25 \text{ yr} \times 50\%}{70 \text{ kg} \times 0.25 \text{ yr} \times 365 \text{ day/yr} \times 10^6 \text{ mg/kg}}$$

$$= 1.2 \times 10^{-6} \text{ mg/kg/day}$$

$$\text{1,1,1-TCA} = \frac{0.007 \text{ mg/kg} \times 1000 \text{ mg/day} \times 65 \text{ days/yr} \times 0.25 \text{ yr} \times 50\%}{70 \text{ kg} \times 0.25 \text{ yr} \times 365 \text{ day/yr} \times 10^6 \text{ mg/kg}}$$

$$= 9.0 \times 10^{-9} \text{ mg/kg/day}$$

$$\text{Mercury} = \frac{14.5 \text{ mg/kg} \times 1000 \text{ mg/day} \times 65 \text{ days/yr} \times 0.25 \text{ yr} \times 1\%}{70 \text{ kg} \times 0.25 \text{ yr} \times 365 \text{ day/yr} \times 10^6 \text{ mg/kg}}$$

$$= 3.7 \times 10^{-7} \text{ mg/kg/day}$$

$$\text{Hazard Index} = \text{1,1-DCE: } \frac{1.2 \times 10^{-6}}{9.0 \times 10^{-3}} = 1.3 \times 10^{-4}$$

$$\text{1,1,1-TCA: } \frac{9.0 \times 10^{-9}}{9.0 \times 10^{-1}} = 1.0 \times 10^{-8}$$

$$\text{Mercury: } \frac{3.7 \times 10^{-7}}{3.0 \times 10^{-4}} = 1.2 \times 10^{-3}$$

$$\textit{TOTAL} = 1.3 \times 10^{-3}$$

$$\textit{Exposure Dose } (mg/kg/day) = \frac{C \times IR \times EF \times ED \times RAF}{BW \times AVG \times 365 \; days/year \times 10^6 \; mg/kg}$$

$$1{,}1\text{-DCE} = \frac{0.947 \; mg/kg \times 50 \; mg/day \times 65 \; days/yr \times 0.25 \; yr \times 100\%}{70 \; kg \times 70 \; yr \times 365 \; day/yr \times 10^6 \; mg/kg}$$

$$= 4.3 \times 10^{-10} \; mg/kg/day$$

$$\text{Excess Risk} = \text{Exposure Dose} \times \text{Potency Value}$$

$$= 4.3 \times 10^{-10} \; mg/kg/day \times \frac{6 \times 10^{-1}}{mg/kg/day}$$

$$= 2.6 \times 10^{-10}$$

$$Exposure\ Dose\ (mg/kg/day) = \frac{C \times SCR \times EF \times ED \times RAF}{BW \times AVG \times 365\ days/year \times 10^{6}\ mg/kg}$$

$$1{,}1\text{-DCE} = \frac{0.947\ mg/kg \times 1000\ mg/day \times 65\ days/yr \times 0.25\ yr \times 50\%}{70\ kg \times 70\ yr \times 365\ day/yr \times 10^{6}\ mg/kg}$$

$$= 4.3 \times 10^{-9}\ mg/kg/day$$

$$\text{Excess Risk} = \text{Exposure Dose} \times \text{Potency Value}$$

$$= 4.3 \times 10^{-9}\ mg/kg/day \times \frac{6 \times 10^{-1}}{mg/kg/day}$$

$$= 2.6 \times 10^{-9}$$

$$\textit{Exposure Dose (mg/kg/day)} = \frac{C \times IR \times EF \times ED \times RAF}{BW \times AVG \times 365 \text{ days/year} \times 10^6 \text{ mg/kg}}$$

$$\text{1,1-DCE} = \frac{0.947 \text{ mg/kg} \times 200 \text{ mg/day} \times 273 \text{ days/yr} \times 6 \text{ yr} \times 100\%}{16 \text{ kg} \times 6 \text{ yr} \times 365 \text{ day/yr} \times 10^6 \text{ mg/kg}}$$

$$= 8.8 \times 10^{-6} \text{ mg/kg/day}$$

$$\text{1,1,1-TCA} = \frac{0.007 \text{ mg/kg} \times 200 \text{ mg/day} \times 273 \text{ days/yr} \times 6 \text{ yr} \times 100\%}{16 \text{ kg} \times 6 \text{ yr} \times 365 \text{ day/yr} \times 10^6 \text{ mg/kg}}$$

$$= 6.5 \times 10^{-8} \text{ mg/kg/day}$$

$$\text{Mercury} = \frac{14.5 \text{ mg/kg} \times 200 \text{ mg/day} \times 273 \text{ days/yr} \times 6 \text{ yr} \times 100\%}{16 \text{ kg} \times 6 \text{ yr} \times 365 \text{ day/yr} \times 10^6 \text{ mg/kg}}$$

$$= 1.4 \times 10^{-4} \text{ mg/kg/day}$$

$$\text{Hazard Index} = \text{1,1-DCE: } \frac{8.8 \times 10^{-6}}{9.0 \times 10^{-3}} = 9.8 \times 10^{-4}$$

$$\text{1,1,1-TCA: } \frac{6.5 \times 10^{-8}}{9.0 \times 10^{-2}} = 7.2 \times 10^{-7}$$

$$\text{Mercury: } \frac{1.4 \times 10^{-4}}{3.0 \times 10^{-4}} = 4.6 \times 10^{-1}$$

$$\textit{TOTAL} = 4.6 \times 10^{-1}$$

$$\textit{Exposure Dose (mg/kg/day)} = \frac{C \times SCR \times EF \times ED \times RAF}{BW \times AVG \times 365\ days/year \times 10^6\ mg/kg}$$

$$\text{1,1-DCE} = \frac{0.947\ mg/kg \times 500\ mg/day \times 273\ days/yr \times 6\ yr \times 50\%}{16\ kg \times 6\ yr \times 365\ day/yr \times 10^6\ mg/kg}$$

$$= 4.4 \times 10^{-11}\ mg/kg/day$$

$$\text{1,1,1-TCA} = \frac{0.007\ mg/kg \times 500\ mg/day \times 273\ days/yr \times 6\ yr \times 50\%}{16\ kg \times 6\ yr \times 365\ day/yr \times 10^6\ mg/kg}$$

$$= 8.2 \times 10^{-8}\ mg/kg/day$$

$$\text{Mercury} = \frac{14.5\ mg/kg \times 500\ mg/day \times 273\ days/yr \times 6\ yr \times 1\%}{16\ kg \times 6\ yr \times 365\ day/yr \times 10^6\ mg/kg}$$

$$= 3.4 \times 10^{-6}\ mg/kg/day$$

$$\text{Hazard Index} = \text{1,1-DCE: } \frac{4.4 \times 10^{-11}}{9.0 \times 10^{-3}} = 5.0 \times 10^{-9}$$

$$\text{1,1,1-TCA: } \frac{8.2 \times 10^{-8}}{9.0 \times 10^{-1}} = 9.1 \times 10^{-8}$$

$$\text{Mercury: } \frac{3.4 \times 10^{-6}}{3.0 \times 10^{-4}} = 1.1 \times 10^{-2}$$

$$\textit{TOTAL} = 1.1 \times 10^{-2}$$

$$\textit{Exposure Dose } (mg/kg/day) = \frac{C \times SCR \times EF \times ED \times RAF}{BW \times AVG \times 365 \ days/year \times 10^6 \ mg/kg}$$

$$\text{1,1-DCE} = \frac{0.947 \ mg/kg \times 500 \ mg/day \times 273 \ days/yr \times 6 \ yr \times 50\%}{16 \ kg \times 70 \ yr \times 365 \ day/yr \times 10^6 \ mg/kg}$$

$$= 9.5 \times 10^{-7} \ mg/kg/day$$

$$\text{Excess Risk} = \text{Exposure Dose} \times \text{Potency Value}$$

$$= 9.5 \times 10^{-7} \ mg/kg/day \times \frac{6 \times 10^{-1}}{mg/kg/day}$$

$$= 5.7 \times 10^{-7}$$

Future Resident, Child (age 1–6)
Ingestion of Soil

$$\textit{Exposure Dose (mg/kg/day)} = \frac{C \times IR \times EF \times ED \times RAF}{BW \times AVG \times 365\ days/year \times 10^{6}\ mg/kg}$$

$$\text{1,1-DCE} = \frac{0.947\ mg/kg \times 200\ mg/day \times 273\ days/yr \times 6\ yr \times 100\%}{16\ kg \times 70\ yr \times 365\ day/yr \times 10^{6}\ mg/kg}$$

$$= 7.6 \times 10^{-7}\ mg/kg/day$$

Excess Risk = Exposure Dose × Potency Value

$$= 7.6 \times 10^{-7}\ mg/kg/day \times \frac{6 \times 10^{-1}}{mg/kg/day}$$

$$= 4.6 \times 10^{-7}$$

$$\text{Exposure Dose (mg/kg/day)} = \frac{C \times SCR \times EF \times ED \times RAF}{BW \times AVG \times 365\ days/year \times 10^6\ mg/kg}$$

$$\text{1,1-DCE} = \frac{0.947\ mg/kg \times 500\ mg/day \times 273\ days/yr \times 6\ yr \times 50\%}{16\ kg \times 70\ yr \times 365\ day/yr \times 10^6\ mg/kg}$$

$$= 9.5 \times 10^{-7}\ mg/kg/day$$

$$\text{Excess Risk} = \text{Exposure Dose} \times \text{Potency Value}$$

$$= 9.5 \times 10^{-7}\ mg/kg/day \times \frac{6 \times 10^{-1}}{mg/kg/day}$$

$$= 5.7 \times 10^{-7}$$

Future Resident (age 6–30)
Ingestion of Soil

$$Exposure\ Dose\ (mg/kg/day) = \frac{C \times IR \times EF \times ED \times RAF}{BW \times AVG \times 365\ days/year \times 10^6\ mg/kg}$$

$$1,1\text{-DCE} = \frac{0.947\ mg/kg \times 100\ mg/day \times 273\ days/yr \times 24\ yr \times 100\%}{70\ kg \times 24\ yr \times 365\ day/yr \times 10^6\ mg/kg}$$

$$= 1.0 \times 10^{-6}\ mg/kg/day$$

$$1,1,1\text{-TCA} = \frac{0.007\ mg/kg \times 100\ mg/day \times 273\ days/yr \times 24\ yr \times 100\%}{70\ kg \times 24\ yr \times 365\ day/yr \times 10^6\ mg/kg}$$

$$= 7.5 \times 10^{-9}\ mg/kg/day$$

$$\text{Mercury} = \frac{14.5\ mg/kg \times 100\ mg/day \times 273\ days/yr \times 24\ yr \times 100\%}{70\ kg \times 24\ yr \times 365\ day/yr \times 10^6\ mg/kg}$$

$$= 1.5 \times 10^{-5}\ mg/kg/day$$

$$\text{Hazard Index} = 1,1\text{-DCE:}\ \frac{1.0 \times 10^{-6}}{9.0 \times 10^{-3}} = 1.1 \times 10^{-4}$$

$$1,1,1\text{-TCA:}\ \frac{7.5 \times 10^{-9}}{9.0 \times 10^{-2}} = 8.3 \times 10^{-8}$$

$$\text{Mercury:}\ \frac{1.5 \times 10^{-5}}{3.0 \times 10^{-4}} = 5.0 \times 10^{-2}$$

$$TOTAL = 5.0 \times 10^{-2}$$

$$\textit{Exposure Dose (mg/kg/day)} = \frac{C \times SCR \times EF \times ED \times RAF}{BW \times AVG \times 365 \textit{ days/year} \times 10^{6} \textit{ mg/kg}}$$

$$\text{1,1-DCE} = \frac{0.947 \textit{ mg/kg} \times 500 \textit{ mg/day} \times 273 \textit{ days/yr} \times 24 \textit{ yr} \times 50\%}{16 \textit{ kg} \times 24 \textit{ yr} \times 365 \textit{ day/yr} \times 10^{6} \textit{ mg/kg}}$$

$$= 2.5 \times 10^{-6} \textit{ mg/kg/day}$$

$$\text{1,1,1-TCA} = \frac{0.007 \textit{ mg/kg} \times 500 \textit{ mg/day} \times 273 \textit{ days/yr} \times 24 \textit{ yr} \times 50\%}{70 \textit{ kg} \times 24 \textit{ yr} \times 365 \textit{ day/yr} \times 10^{6} \textit{ mg/kg}}$$

$$= 1.9 \times 10^{-8} \textit{ mg/kg/day}$$

$$\text{Mercury} = \frac{14.5 \textit{ mg/kg} \times 500 \textit{ mg/day} \times 273 \textit{ days/yr} \times 24 \textit{ yr} \times 1\%}{70 \textit{ kg} \times 24 \textit{ yr} \times 365 \textit{ day/yr} \times 10^{6} \textit{ mg/kg}}$$

$$= 7.7 \times 10^{-7} \textit{ mg/kg/day}$$

$$\text{Hazard Index} = \text{1,1-DCE: } \frac{2.5 \times 10^{-6}}{9.0 \times 10^{-3}} = 2.8 \times 10^{-4}$$

$$\text{1,1,1-TCA: } \frac{1.9 \times 10^{-8}}{9.0 \times 10^{-2}} = 2.1 \times 10^{-7}$$

$$\text{Mercury: } \frac{7.7 \times 10^{-7}}{3.0 \times 10^{-4}} = 2.6 \times 10^{-3}$$

$$\textit{TOTAL} = 2.9 \times 10^{-3}$$

$$\textit{Exposure Dose (mg/kg/day)} = \frac{C \times IR \times EF \times ED \times RAF}{BW \times AVG \times 365 \; days/year \times 10^6 \; mg/kg}$$

$$\text{1,1-DCE} = \frac{0.947 \; mg/kg \times 200 \; mg/day \times 273 \; days/yr \times 24 \; yr \times 100\%}{70 \; kg \times 70 \; yr \times 365 \; day/yr \times 10^6 \; mg/kg}$$

$$= 3.5 \times 10^{-7} \; mg/kg/day$$

$$\text{Excess Risk} = \text{Exposure Dose} \times \text{Potency Value}$$

$$= 3.5 \times 10^{-7} \; mg/kg/day \times \frac{6 \times 10^{-1}}{mg/kg/day}$$

$$= 2.1 \times 10^{-7}$$

Future Resident (age 6-30)
Dermal Contact with Soil

$$\text{Exposure Dose (mg/kg/day)} = \frac{C \times SCR \times EF \times ED \times RAF}{BW \times AVG \times 365\ days/year \times 10^6\ mg/kg}$$

$$\text{1,1-DCE} = \frac{0.947\ mg/kg \times 500\ mg/day \times 273\ days/yr \times 24\ yr \times 50\%}{70\ kg \times 70\ yr \times 365\ day/yr \times 10^6\ mg/kg}$$

$$= 8.7 \times 10^{-7}\ mg/kg/day$$

Excess Risk = Exposure Dose × Potency Value

$$= 8.7 \times 10^{-7}\ mg/kg/day \times \frac{6 \times 10^{-1}}{mg/kg/day}$$

$$= 5.2 \times 10^{-7}$$